CLAIMS

We Claim:

1. A method for depositing an epitaxial thin film having the quaternary formula YCZN wherein Y is a Group IV element and Z is a Group III element on a substrate at temperature between ambient temperature and 1000°C in a gas source molecular beam epitaxial chamber, comprising introducing into said chamber:

   i. gaseous flux of precursor H_3YCN wherein H is hydrogen or deuterium; and

   ii. vapor flux of Z atoms;

   under conditions whereby said precursor and said Z atoms combine to form epitaxial YCZN on said substrate.

2. The method of Claim 1 wherein said temperature is about 550°C to 750°C.

3. The method of Claim 1 wherein said substrate is silicon or silicon carbide.

4. The method of Claim 3 wherein said substrate is Si(111) or α-SiC(0001).

5. The method of Claim 3 wherein said substrate is a large-diameter silicon wafer.

6. The method of Claim 5 wherein said silicon wafer comprises Si(111).

7. The method of Claim 4 wherein said substrate is α-SiC(0001) comprising the additional step of cleaning said substrate prior to deposition of said quaternary film.

8. The method of Claim 7 wherein said cleaning step comprises hydrogen etching.

9. The method of Claim 1 wherein said substrate is Si(111) comprising a buffer layer, and said epitaxial semiconductor is deposited on said buffer layer.

10. The method of Claim 7 wherein said buffer layer is a Group III nitride.

11. The method of Claim 8 wherein said buffer layer is AlN.

12. Layered semiconductor structure made by the method of Claim 9.

13. A microelectronic or optoelectronic device comprising a layered semiconductor structure of Claim 12.

14. The method of Claim 1 wherein Y is silicon, germanium or tin.

15. The method of Claim 1 wherein Z is aluminum, gallium or indium.

16. The method of Claim 1 wherein Z is boron.

17. The method of Claim 1 for depositing thin film YCZN wherein Y is silicon and said precursor is H_3SiCN.

18. The method of Claim 1 for depositing the thin film YCZN wherein Y is germanium and said precursor is H_3GeCN.

19. The method of Claim 1 for depositing epitaxial thin film SiCZN on a substrate wherein said precursor is H_3SiCN, said Z atom is aluminum and said substrate is Si(111) or α-SiC(0001).

20. The method of Claim 1 for depositing epitaxial thin film GeCZN on a substrate wherein said precursor is D_3GeCN, said Z atom is aluminum and said substrate is Si(111) or α-SiC(0001).

21. Epitaxial thin film having the formula YCZN wherein Y is a Group IV element and Z is a Group III element or a transition metal, made by the method of Claim 1.

22. Epitaxial thin film having the formula YCZN wherein Y is a Group IV element and Z is a Group III element or a transition metal, made by the method of Claim 5.

23. Epitaxial thin film semiconductor having the formula SiCAIN made by the method of Claim 5.

24. Epitaxial thin film semiconductor made by the method of Claim 1, said semiconductor having the quaternary formula YCZN wherein Y is a Group IV element and Z is aluminum, gallium or indium.

25. Optoelectronic device comprising epitaxial thin film semiconductor of Claim 24.

26. Optoelectronic device of Claim 25 wherein said semiconductor is SiCAIN or GeCAIN.

27. Microelectronic devices comprising epitaxial thin film semiconductor of Claim 24.

28. Microelectronic device of Claim 27 wherein said semiconductor is SiCAIN or GeCAIN.

29. Multi-quantum-well structures comprising epitaxial film semiconductor of Claim 24.

30. Light-emitting diodes and laser diodes comprising multi-quantum well structures of Claim 29.

31. Precursor for the synthesis of epitaxial semiconductors having the formula YCZN wherein Y is a Group IV element and Z is selected from the group comprising aluminum, gallium and indium, said precursor having the formula H_3YCN wherein H is hydrogen or deuterium.

32. Precursor of Claim 31 having the formula H_3SiCN

33. Precursor of Claim 31 having the formula H_3GeCN.

34. The method of Claim 1 for depositing epitaxial thin film having the formula $(YC)_{(0.5-x)}(ZN)_{(0.5+x)}$ wherein x is chosen to be a value $0<x> 0.5$, and Z is the same or different in each occurrence, comprising in addition the step of introducing into said chamber a flux of nitrogen atoms and maintaining the flux of said precursor, said nitrogen atoms and said Z atoms at a ratio selected to produce quaternary semiconductors having said chosen value of x.

35. Epitaxial thin film made by the method of Claim 34.

36. Optoelectronic device comprising epitaxial thin film of Claim 35.

37. Microelectronic device comprising epitaxial thin film of Claim 35.

38. The method of Claim 34 for producing a quaternary YCZN semiconductor having a desired bandgap, YC and ZN having different bandgaps and Y and Z being the same or different in each occurrence, wherein the flux of precursor, Z atoms and N atoms is maintained at a ratio known to produce a film having the desired bandgap.

39. Multi-quantum-well structures comprising epitaxial films of Claim 35.

40. Light-emitting diodes and laser diodes comprising multi-quantum well structures of Claim 39.

41. An optoelectronic device comprising a semiconductor device of Claim 35.

42. Optoelectronic device of Claim 41 selected from the group comprising light-emitting diodes, laser diodes, field emission flat-panel displays and ultraviolet detectors and sensors.

43. Superhard coating made by the method of Claim 1.

44. Superhard coating of Claim 43 wherein Z is boron.

45. Large-area substrate of SiCAlN grown on large diameter Si(111) wafers by the method of Claim 5 for the growth of conventional Group III nitride films.